Effects of short-term drought on the avifauna of Wanjarri Nature Reserve: What do they tell us about drought refugia?

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Abstract

A bird survey in the Wanjarri Nature Reserve in the Goldfields of Western Australia at the end of a year long drought revealed two responses to the short-term dry spell. Firstly, many bird populations were present in very low numbers. Secondly, areas of groving and creekline mulga supported a significantly higher number of bird species and individuals than other habitats. This was thought to be due to the greater foliage cover in groving and creekline mulga, probably as a consequence of soil structure, greater water availability and higher soil fertility. These areas of groving and creekline mulga may be important as drought refugia for resident bird species. Our results need to be confirmed by a more comprehensive study but the identification of drought refugia is of fundamental importance in the conservation of birds in the arid-zone of Australia, so we believe that the conservation of these groving and creekline mulga areas should be given a high priority.

Keywords: birds, drought refugia, mulga, spinifex, foliage cover, conservation, landscape

Introduction

Arid habitats, especially those in Australia, are characterised by the unpredictable nature of resource availability. Rainfall is spatially and temporally erratic and this leads to large fluctuations in faunal biomass and productivity in any particular area (Stafford-Smith & Morton 1990). Birds in the arid-zone adapt to the ephemeral nature of available resources in two ways. The first group, characterised by many honeyeaters, are highly mobile and cover large areas in their search for suitable habitats. Their strategy is to be mobile enough so that they can always find areas of recent rainfall, hence high biomass and productivity, no matter where they occur (Davies 1986). The second group, characterised by thornbills and robins, are resident and relatively non-mobile. Their strategy is to eke out an existence in drought refugia during periods of low rainfall. After heavy rains, populations in the drought refugia increase and move out into previously unsuitable habitat to take advantage of the increased productivity (Davies 1986). During drought, most populations die out and only those located in drought refugia persist. Their survival strategy approximates a "core-satellite" population model (Boorman & Levitt 1973; Hanski 1982) where some habitats that support populations which persist for long periods of time are surrounded by habitats that are occupied only part of the time, usually when conditions are favourable (Harrison 1991).

Conservation and management of the first group of highly-mobile birds within a reserve system is difficult due to the unpredictable nature of their occurrence, both temporally and spatially. Reservation of a particular area will seldom satisfy their conservation needs because the areas they cover are so large. Members of the second group of resident birds are easier to conserve and manage within a reserve system because all their needs can be provided within a relatively small area. One of the main objectives in conserving and managing relatively non-mobile species is to locate and identify their refugia. Drought refugia are likely to be of fundamental importance because they provide the only suitable habitat for these species during dry conditions, so the loss of these areas will lead to local extinction (Davies 1986). It has been postulated that the degradation of relatively fertile drought refugia was largely responsible for the extinction of almost all medium-sized mammals in the arid-zone of Australia (Morton 1990).

In September 1994, we examined patterns of habitat use by birds during a short drought at Wanjarri Nature Reserve (27° 25' S, 120° 40' E; 500 m asl) in the Goldfields region of Western Australia. Wanjarri (53 248 ha) is located within the Murchison Interim Biogeographic Regionalisation for Australia (IBRA) Region (formerly the Austin Vegetation District), which is the second largest IBRA Region in WA (Thackway & Cresswell 1995). Its vegetation, soils and fauna have been affected by pastoral activity. Although the reserve was relinquished as a pastoral lease in 1971, the effects of grazing were still apparent; 75% of the reserve was in 'good' resource condition, 23% in 'fair' and 2% in 'poor' in 1992 (Pringle 1995). Wanjarri is ideal for studies of drought refugia because it is located well within the arid-zone, so patterns found here are likely to be applicable to other arid areas, and results have relevance to both pristine and grazing affected vegetation in the arid-zone. While our results do not provide unequivocal evidence, we believe that the patterns we observed provide a strong indication as to which habitats act as drought refugia.

Methods

Bird censuses were carried out from 30th August to 4th September 1994 between 0730 and 1700 at 21 sites in Wanjarri Nature Reserve. Birds were assessed by the square transect method (Biological Survey Committee 1984). At most sites we set up two 200 x 200 m square grids. Both authors walked the four sides and one diagonal of one square at each site, over approximately 45 minutes, and recorded all birds seen or heard within 30 m of either side of the transect line. On those sites where the habitat features were linear (such as creeklines and breakaways), we conducted counts on two linear 1080 m transects rather than 200 x 200 m squares. At all sites, we added the results from the two censuses. Birds seen or heard outside the 60 meter transect band, or only seen flying overhead, were recorded as opportunistic records. The time at which censuses were conducted in different habitats was randomised with respect to time of day to reduce any bias from variations in bird activity through the day. The counts in 1994 were conducted in what we considered drought conditions, because only 87.4 mm of rain had fallen in the 12 months prior to September 1994 at Albion Downs, 30 km N of Wanjarri (Fig 1). This compares with the average annual rainfall at Albion Downs of 237.8 mm.

Habitats

The 21 sites censused for birds were divided into four broad habitat types; (1) groving and creekline mulga communities (5 sites), (2) open mulga communities (5 sites), (3) spinifex communities (4 sites), and (4) other communities (7 sites). The four community types were defined as follows;

(1) groving and creekline mulga communities: those where mulga (*Acacia aneura*) grew to 10 m in either major shallow drainages, which were up to 350 m wide, or where mulga occurred in discrete groves independent of any co-ordinated drainage. In landscape terms, the drainages formed corridors of denser vegetation between the granite-dominated high points and the lower spinifex plains. Foliage cover was usually around 25-30%. A wide variety of shrubs and grasses were often present, including *Grevillea sarissa*, *Rhagodia eremaea*, *Solanum lasiophyllum* and *Gnephosis foliata*, and dense leaf litter, sometimes redistributed by flooding, was usually a feature of this community type.

(2) open mulga communities: those where mulga was the structurally dominant plant as either a small tree or a shrub. Foliage cover was around 15-20%. A wide variety of lower shrubs or grasses were often present, including *Acacia ligulata*, *Eremophila fraseri*, *Eragrostis eriopoda* and *Aristida contorta*. When *Triodia basdowii* was present, it was relatively uncommon and did not achieve the large clump size that it did on sandier soils.

(3) spinifex communities: those in which *Triodia basdowii* was the dominant plant species and formed a foliage cover of 30-70%. Spinifex communities occurred either on open plains or as a dune/swale sequence. When they occurred on open plains, the overstorey was dominated by either mallees (*Eucalyptus oldfieldii* and *E. leptopoda*) or wattles (*Acacia aneura*, *A. pachyacra* and *A. coolgardiensis*) depending on soil characteristics. When they occurred as a dune/swale sequence, then *E. gongylocarpa*, *Grevillea pterosperma* and *A. ligulata* were the

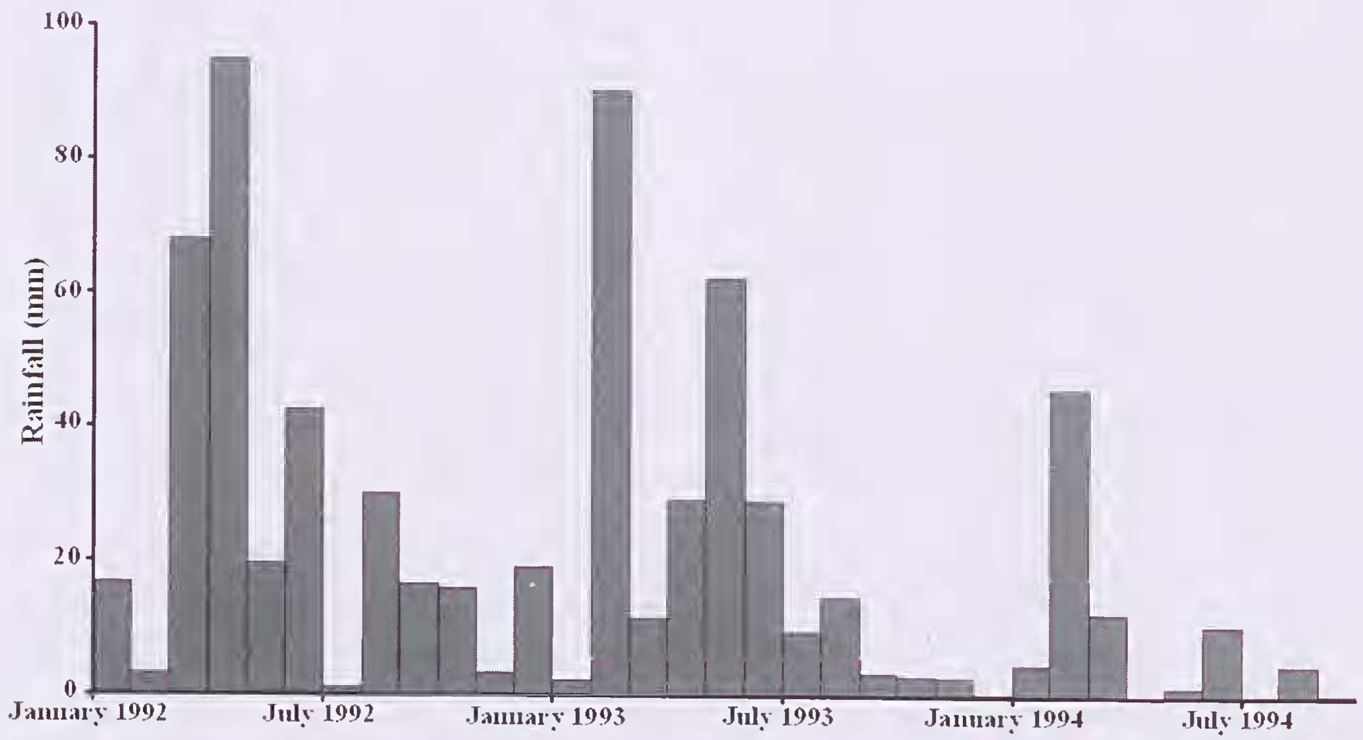

Figure 1. Monthly rainfall data for Albion Downs station about 30 km N of Wanjarri from January 1992 until September 1994. Note that the six months prior to the September 1994 survey were very dry although February 1994 had been relatively wet.

dominant overstorey species on the dune and *Thryptomene maisonneuvii* and *A. coolgardiensis* were the dominant overstorey species in the swale.

(4) other communities: this included a variety of community types that differ greatly from the other three. Examples in this study were riverbeds lined with *E. camaldulensis*, chenopod flats, stony plains and breakaways.

Statistical analyses

The number of species and individuals recorded per site was compared using a one-way ANOVA with Fisher's PLSD for post-hoc testing. Analyses were conducted using SuperANOVA 1.11 (Abacus Concepts 1993). The α–value for significance was 0.05.

Results

A total of 38 species was recorded during the bird transects in September 1994 (Table 1), comprising 293 individuals at an average of 9.3 birds person hr^{-1}. Some species, such as Chestnut-rumped Thornbill, Yellow-rumped Thornbill and Southern Whiteface (see Table 1 for scientific names), managed to maintain relatively high numbers despite the dry conditions. However, the overall pattern was for low numbers, especially among nomadic species and raptors.

The number of species recorded differed significantly ($F_{3,17} = 5.33$, $P = 0.009$) between the four habitat groups (Table 2). Areas of groving and creekline mulga supported a significantly higher number of species than the other habitat groups, although there was no significant difference between the number of species in the remaining three habitat groups (Table 1). The number of individuals also differed significantly ($F_{3,17} = 5.37$, $P = 0.009$) between the four habitat groups (Table 2). Again, the number of individuals in groving and creekline mulga were significantly higher than the other three habitat groups which between them showed no significant difference (Table 2).

Table 1

Numbers of individual species recorded in each of four habitats at Wanjarri Nature Reserve. Values are the mean number of individuals per site (± se for species where n > 2; n is the total number of individuals sighted on all sites).

Species	n	Groving mulga (5 sites)	Open mulga (5 sites)	Spinifex (4 sites)	Other (7 sites)
Brown Falcon (*Falco berigora*)	1	0	0	0.25	0
Nankeen Kestrel (*Falco cenchroides*)	1	0	0	0	0.14
Common Bronzewing (*Phaps chalcoptera*)	2	0.40	0	0	0
Galah (*Cacatua roseicapilla*)	10	1.40 ± 1.17	0	0	0.43 ± 0.43
Port Lincoln Ringneck (*Barnardius zonarius*)	9	0.60 ± 0.40	0	0	0.86 ± 0.86
Tawny Frogmouth (*Podargus strigoides*)	2	0	0	0	0.29
Red-capped Robin (*Petroica goodenovii*)	5	0.60 ± 0.24	0	0	0.29 ± 0.18
Hooded Robin (*Melanodryas cucullatus*)	4	0.20 ± 0.20	0	0	0.43 ± 0.43
Rufous Whistler (*Pachycephala rufiventris*)	3	0.40 ± 0.24	0.20 ± 0.20	0	0
Grey Shrike-thrush (*Colluricincla harmonica*)	1	0.20	0	0	0
Crested Bellbird (*Oreoica gutturalis*)	8	0.40 ± 0.40	1.00 ± 0.77	0	0.14 ± 0.14
Willie Wagtail (*Rhipidura leucophrys*)	6	0.20 ± 0.20	0.60 ± 0.60	0	0.29 ± 0.29
Chestnut-breasted Quail-thrush (*Cinclosoma castaneothorax*)	4	0	0	0	0.57 ± 0.57
Grey-crowned Babbler (*Pomatostomus temporalis*)	9	0	1.80 ± 1.80	0	0
White-browed Babbler (*Pomatostomus superciliosus*)	6	1.20 ± 1.20	0	0	0
Unidentified Fairy-wren (*Malurus* sp.)	3	0.60 ± 0.60	0	0	0
Rufous-crowned Emu-wren (*Stipiturus ruficeps*)	1	0	0	0.25	0
Striated Grasswren (*Amytornis striatus*)	1	0	0	0.25	0
Weebill (*Smicrornis brevirostris*)	1	0	0	0.25	0
Inland Thornbill (*Acanthiza apicalis*)	9	1.00 ± 0.77	0.20 ± 0.20	0.25 ± 0.25	0.29 ± 0.29
Slaty-backed Thornbill (*Acanthiza robustirostris*)	13	2.40 ± 1.03	0	0	0.14 ± 0.14
Chestnut-rumped Thornbill (*Acanthiza uropygialis*)	70	7.00 ± 1.64	0.40 ± 0.40	1.75 ± 1.75	3.71 ± 0.97
Yellow-rumped Thornbill (*Acanthiza chrysorrhoa*)	24	1.00 ± 0.45	0.40 ± 0.40	0	2.43 ± 1.66
Southern Whiteface (*Aphelocephala leucopsis*)	17	3.00 ± 0.95	0	0	0.29 ± 0.29
Varied Sittella (*Daphoenositta chrysoptera*)	5	1.00 ± 1.00	0	0	0
White-browed Treecreeper (*Climacteris affinis*)	8	1.60 ± 0.93	0	0	0
Yellow-throated Miner (*Manorina flavigula*)	11	1.40 ± 0.98	0.20 ± 0.20	0.75 ± 0.75	0
Singing Honeyeater (*Lichenostomus virescens*)	6	0.40 ± 0.24	0.20 ± 0.20	0	0.29 ± 0.29
Grey-fronted Honeyeater (*Lichenostomus plumulus*)	7	0	0	1.75 ± 1.18	0
White-fronted Honeyeater (*Phylidonyris albifrons*)	4	0	0.20 ± 0.20	0	0.43 ± 0.43
Zebra Finch (*Poephila guttata*)	1	0	0	0	0.14
Black-faced Woodswallow (*Artamus cinereus*)	25	0	4.00 ± 1.82	0	0.71 ± 0.71
Grey Butcherbird (*Cracticus torquatus*)	2	0.20	0.20	0	0
Pied Butcherbird (*Cracticus nigrogularis*)	8	0.20 ± 0.20	0.40 ± 0.40	0	0.71 ± 0.47
Australian Magpie (*Gymnorhina tibicen*)	1	0	0.20	0	0
Little Crow (*Corvus bennettii*)	7	0	1.40 ± 1.40	0	0
Torresian Crow (*Corvus orru*)	1	0	0.20	0	0

Table 2

Number of species and individuals recorded in each habitat group for Wanjarri Nature Reserve. Values are mean ± se; *n* is the number of sites in each habitat group; values with different superscript letters are significantly different.

Habitat type	*n*	# of species	# of individuals
Groving or creekline mulga	5	8.60 ± 1.50[a]	25.00 ± 3.39[a]
Open mulga	5	3.60 ± 1.50[b]	11.80 ± 4.79[b]
Spinifex	4	2.25 ± 0.95[b]	5.25 ± 2.10[b]
Other communities	7	3.86 ± 0.74[b]	12.57 ± 2.44[b]

Table 3

Numbers of raptors and all birds sighted during this study at Wanjarri Nature Reserve, compared to Hall *et al.* (1994). All values are number of individuals sighted per person hour.

	This study	Hall *et al.* (1994)		
	September 1994	February 1979	May 1980	August 1981
Raptors	0.06	0.28	0.48	0.92
All birds	9.3	17.3	23.4	37.4

Discussion

The data obtained in this survey at Wanjarri Nature Reserve support two notable aspects of faunal response to short-term dry conditions. The first aspect is that the number of bird species and individuals was low during the drought conditions of our study. Although we recorded most resident passerine species in the reserve (Moriarty 1972), the number of individuals that we recorded (Table 3) was low compared to the intensive study of the reserve conducted by Hall *et al.* (1994), even though we recorded all the resident passerine species they did. In addition, the number of raptors that we sighted (Table 3) was also low compared to Hall *et al.* (1994). Additional evidence of stress was the absence of breeding records during the survey, despite the survey having been conducted at a time when many species would be expected to breed. These observations suggest that that biological productivity was low during the drought conditions of our study.

The second aspect was that the decline in avian species richness and abundance at Wanjarri differed considerably between groving/creekline mulga and other habitats. Areas of groving and creekline mulga supported a much higher number of birds, both species and individuals, than the other habitats. This suggests that these areas act as drought refugia for resident birds during drought conditions. The 14 bird species that were most common in groving and creekline mulga (Table 1) are considered to be resident (Blakers *et al.* 1984; Higgins 1999; Higgins *et al.* 2001). They include nine species that can be reliably recorded in mulga communities across Australia (Galah, Red-capped Robin, Rufous Whistler, Grey Shrike-thrush, White-browed Babbler, Inland Thornbill, Chestnut-rumped Thornbill, Southern Whiteface and Singing Honeyeater) and four species that are considered peripheral in mulga communities (Common Bronzewing, White-browed Treecreeper, Yellow-throated Miner and Slaty-backed Thornbill; Cody 1994). The high numbers of bird species and individuals recorded from groving and creekline mulga communities in this study were in sharp contrast to the spinifex-dominated habitats.

So what are the habitat characteristics and parameters of groving and creekline mulga that allow birds to persist there in dry conditions? The most obvious characteristic is that they have a much greater vegetation density than other habitats. The five creekline and groving mulga communities had an average of 25 to 30% foliage cover, whereas open mulga communities had an average of only 15 to 20% (H Pringle, Department of Agriculture, unpublished data). Groving and creekline mulga areas probably have greater vegetation density than other habitats because of differences in soil structure and the greater availability of water and nutrients. In contrast to open mulga soils, the soils of groving and creekline mulga areas usually have a shallow A horizon and subsequent horizons in the same texture group as the A horizon leading to less resistance to root penetration (P Hennig, Department of Agriculture, unpublished data). In addition, soils of groving and creekline mulga have stable macropores that enable them to absorb up to 10 times the amount of water of open mulga soils (Greene 1992). This greater water availability is accentuated because groving and creekline mulga occupies low points in the landscape, where water and nutrients tend to collect (Tongway 1990; Tongway & Ludwig 1990; Ludwig *et al.* 1994). In contrast, open mulga communities tend to occur on hardpans and breakaway footslopes where there is less water and nutrients (Tongway & Ludwig 1990; Greene 1992; Ludwig *et al.* 1994). So, plants that grow in areas of groving and creekline mulga have greater access to water and nutrients and can form a denser canopy. Their access to water and nutrients also means that they can maintain greater productivity during dry periods, which presumably supports more invertebrates and, hence, insectivorous birds. It has been shown that areas of groving and creekline mulga support higher densities of terrestrial invertebrates than other habitats (Whitford *et al.* 1992; Noble *et al.* 1996), which may be important as many mulga-inhabiting birds forage on the ground (Recher & Davis 1997). Unfortunately, no comparable information is available on the arboreal invertebrate fauna.

Morton (1990) proposed that vertebrates in arid-zone ecosystems, especially mammals, were dependent on "uncommon pockets of relatively fertile, moist country that are scattered across the arid-zone" to act as refugia in times of drought. The significance of this to the conservation and management of arid-zone vertebrates is that the degradation of these drought refugia, by feral or introduced herbivores, changed fire regimes, or predation by introduced mammals, could cause species extinction. Indeed, Morton (1990) proposed that degradation of drought refugia could explain the extinction of large numbers of medium-sized mammals in the arid-zone. Although extinctions in the arid-zone have only occurred among mammal species, there are some indications that we may see loss of biodiversity among the arid-zone avifauna in the near future (Recher & Lim, 1990; Smith *et al.* 1994; Recher 1999). Thus, identification of drought refugia is imperative if we are to maintain avian biodiversity in Australia's arid-zone. To unequivocally identify drought refugia for birds in the arid-zone of Australia, a long-term monitoring project is needed to assess the abundance of birds in all habitats within a landscape and observe how abundance varies when drought periods occur. As far as we are aware, no study of the arid-zone of Australia has yet been conducted over a wide enough range of habitats for a sufficiently long time period to unequivocally identify drought refugia. As our study only used data from a dry period, it cannot provide unequivocal evidence of avian drought refugia. However, the patterns we observed strongly suggest that areas of groving and creekline mulga act as drought refugia for resident arid-zone birds, so there should be a strong focus in arid-zone management to conserve areas of groving and creekline mulga unless a more comprehensive study refutes our findings.

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